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Health and Environmental Effects Profile for Profluralin

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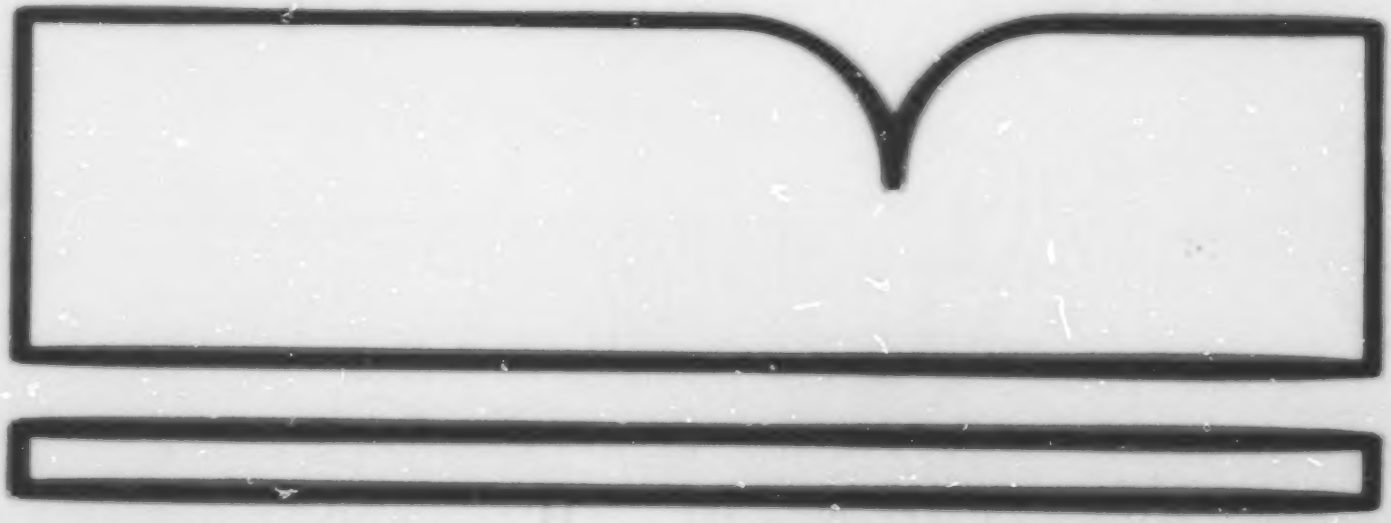

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16. ABSTRACT

The Health and Environmental Effects Profile for profluralin was prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files were evaluated as they pertained to potential human health, aquatic life and environmental effects of hazardous waste constituents.

Quantitative estimates have been presented provided sufficient data are available. Profluralin has been evaluated as a carcinogen. The human carcinogen potency factor (q_1^*) for profluralin is 2.8×10^{-2} (mg/kg bw/day)$^{-1}$ for oral exposure.

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HEALTH AND ENVIRONMENTAL EFFECTS PROFILE FOR PROFLURALIN

ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE
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PREFACE

Health and Environmental Effects Profiles (HEEPs) are prepared for the Office of Solid Waste by the Office of Health and Environmental Assessment. The HEEPs are intended to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files are evaluated as they pertain to potential human health, aquatic life and environmental effects of hazardous waste constituents. The literature searched and the dates of the searches are included in the section titled "Appendix: Literature Searched."

Quantitative estimates are presented provided sufficient data are available. For systemic toxicants, these include, Acceptable Daily Intakes (ADIs) for chronic exposures. An ADI is defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect. In the case of suspected carcinogens, ADIs are not estimated in this document series. Instead, a carcinogenic potency factor or q_1^* is provided. These potency estimates are derived for both oral and inhalation exposures where possible. In addition, unit risk estimates for air and drinking water are presented based on inhalation and oral data, respectively.

The first draft of this document was prepared by Syracuse Research Corporation under EPA Contract No. 68-03-3228. The document was subsequently revised after reviews by staff within the Office of Health and Environmental Assessment: Carcinogen Assessment Group, Reproductive Effects Assessment Group, Exposure Assessment Group, and the Environmental Criteria and Assessment Office in Cincinnati.

The HEEPs will become part of the EPA RCRA docket.

ACKNOWLEDGEMENTS

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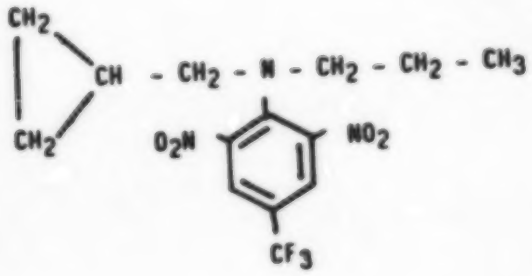
LIST OF ABBREVIATIONS

ADI	Acceptable daily intake
BCF	Bioconcentration factor
LD_{50}	Dose lethal to 50% of recipients
ppb	Parts per billion
ppm	Parts per million
TLV	Threshold limit value
UV	Ultraviolet

1. INTRODUCTION

1.1. STRUCTURE AND CAS NUMBER

Profluralin is also known as 2,6-dintro-4-trifluoromethyl-n-propyl-n-cyclopropylmethylaniline, N-(cyclopropylmethyl)-alpha,alpha,alphatrifluoro-2,6-dinitro-N-propyl-ptoluidine; Tolban; CGA 10832; ER 5461; GA 10832 and Pregard (NIOSH, 1983). The structure of profluralin is shown below:



Emperical formula: $C_{14}H_{16}F_3N_3O_4$

Molecular weight: 347.33

The Chemical Abstracts Service (CAS) Registry number for profluralin is 26399-36-0.

1.2. PHYSICAL AND CHEMICAL PROPERTIES

Profluralin may be in the form of yellow-orange crystals or a deep orange liquid with no appreciable odor (WSSA, 1979). Some of its physical and chemical properties are given below (WSSA, 1979) (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation):

Melting point:	32.1-32.5°C
Boiling point:	sublimes
Specific gravity:	1.45 at 25°C
Vapor pressure:	6.9×10^{-5} mm Hg at 20°C
Water solubility:	0.1 ppm at 27°C

1.3. PRODUCTION DATA

Profluralin is produced by the nitration of 4-trifluoro-methylchlorobenzene and reaction with N-cyclopropylmethyl-N-n-propylamine (Ayers, 1976). The Ciba Geigy Corp., of McIntosh, Alabama, was listed as the sole U.S. producer of profluralin in 1982 (SRI, 1983). No data regarding production volumes of profluralin were located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

1.4. USE DATA

Profluralin is a dinitroaniline herbicide used to control annual grasses and some broadleaf annual weeds on a variety of crops, shrubs and flowers. Profluralin can be applied at pre- or post-planting or at lay by. It is used at rates of 0.5-1.5 lb/acre (WSSA, 1979).

2. ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

Profluralin is expected to be moderately persistent in the environment. While the compound may undergo significant volatilization and photodecomposition, it is routinely incorporated into the soil to reduce such losses. When incorporated into soil, profluralin binds strongly to soil organic matter and may persist until the next growing season. The compound may be decomposed by microbes, chemical reaction and photodecomposition.

Profluralin may enter the atmosphere by volatilization from treated water and soil. Parochetti et al. (1976) studied the loss of ^{14}C profluralin from soil in a laboratory experiment. The compound was applied at 1.68 kg/ha to clay loam (25.8% moisture) and silt loam (25% moisture). Air was passed over the soil (airflow rate = 50 cc/minute, temperature = 50°C) and the vapors evolving from the soil were collected for 3 hours. The loss of profluralin in 3 hours via volatilization from the clay loam and silt loam soils was 17.5 and 10%, respectively. The rate of profluralin dissipation from soil is associated with increased moisture content (WSSA, 1979) and temperature (Parochetti et al., 1976). Approximately 99% of the profluralin in a sterile aqueous incubation mixture was volatilized within 3 days (Stralka and Camper, 1981).

In a laboratory experiment, Kennedy and Talbert (1977) measured the percentage of applied profluralin lost after UV irradiation (peak energy output at 310 nm) of treated soil on a TLC plate. After 24 hours, soils containing 1, 14, 26 and 33% moisture (by weight) lost 14, 58, 81 and 75% of the applied profluralin, respectively. Irradiated (24 hours) dry silt loam thin layers kept at 5 and 45°C lost 6 and 47% of the applied herbicide, respectively. A similarly treated soil thin layer kept at 45°C in the dark lost 34% of the applied herbicide.

Parochetti and Dec (1978) studied the decomposition of profluralin when applied to soil thin layers and exposed to sunlight. Radiolabeled (^{14}C) profluralin was applied (1 kg/ha) to a thin layer of clay loam on a glass plate and exposed to sunlight for 7 days. When compared with similar plates left in the dark, it was observed that 48% of the applied profluralin had photodecomposed. The adsorption and diffusion of profluralin in ten Wisconsin soils has been studied by Jacques and Harvey (1979a). The distribution coefficient, K_d (amount adsorbed: amount in solution), of profluralin in the ten soils ranged from 4.7-38.8 and was associated with organic matter content. When the diffusion of profluralin was measured, the value for the diffusion coefficient of profluralin decreased as soil water content increased. The diffusion coefficient was directly related to the K_d value. Carringer et al. (1975) reported that profluralin was strongly adsorbed to soil organic matter. Organic matter prepared from peaty muck adsorbed 74, 66 and 66% of the profluralin in applied emulsions at concentrations of 2.5, 5.0 and 10.0×10^{-6} M, respectively. When desorbed thrice with water or 1N $CaCl_2$ solution, the total profluralin recovery from treated organic matter was 12.8 or 11.8%, respectively. Montmorillonite prepared from bentonite adsorbed 9, 10 and 10% of the profluralin in applied emulsions at concentrations of 2.5, 5.0 and 10.0×10^{-6} M, respectively. When desorbed thrice with water or 1N $CaCl_2$, the total profluralin recovery from treated montmorillonite was 93.3 or 69%, respectively. Kenaga (1980) reported experimental and calculated soil adsorption coefficients for profluralin of 8600 and 15,500, respectively. These high values predict substantial sorption of profluralin to soil.

Kearney et al. (1976) and Helling and Krivonak (1978) observed strong binding of profluralin to samples of Matapeake loam soil. Profluralin and

tracer ^{14}C-profluralin were added to soil (10 ppm), and the mixture was incubated aerobically in beakers for up to 7 months (Kearney et al., 1976). A benzeneethyl acetate extraction recovered 88 and 84% of the parent compound held for 3 and 7 months, respectively. The percent of bound herbicide (based on combustion to $^{14}CO_2$) after 3, 5 and 7 months of incubation was 18, 28 and 22%, respectively.

The persistence of profluralin in field and laboratory experiments has been studied by many investigators. Profluralin can be dissipated from soil by volatilization, photodecomposition, chemical destruction (Kennedy and Talbert, 1977) and microbial degradation (Stralka and Camper, 1981). However, carryover of soil residues may present a problem in the next growing season (Jacques and Harvey, 1979b). When applied to plots of Plano silt loam at a rate of 1.7 kg/ha, profluralin was detected up to 346 days later. The herbicide was present in the 0-7.5 cm soil layer on days 0, 50, 100 and 346 at concentrations of ~1, 0.65, 0.15 and 0.06 ppm, respectively (Jacques and Harvey, 1979b).

Hayden and Smith (1980) reported that profluralin applied to three Saskatchewan soils (1.5 kg/ha) was detectable up to 17 months after application. The percentage of profluralin remaining 17 months after incorporation into sandy loam, heavy clay and silty clay soils in 1976 was 7, 7 and 16%, respectively. In 1977, the percentage of profluralin remaining 17 months after incorporation into sandy loam, heavy clay and silty clay soils in 1976 was 8, 9 and <2%, respectively. First order decay adequately described the dissipation of profluralin from Crowley silt loam (Brewer et al., 1982). The half-life of the herbicide when applied to an Arkansas rice field in

1978 (0.84 kg/ha) and 1979 (1.68 kg/ha) was 10.9 and 11.5 weeks, respectively. Flooding of rice fields with water during the winter months was observed to increase the dissipation rate of profluralin.

Specific soil microbes capable of degrading profluralin have been .ified. Laanio et al. (1973) reported that dealkylated and polar bolites of ^{14}C-profluralin were produced after 15-17 days of incuba- .on with the soil fungi Aspergillus fumigatus, Fusarium oxysporum and Paecilomyces sp. Less than 1% of the total radioactivity recovered was in the form of $^{14}CO_2$. Stralka and Camper (1981) observed the microbial degradation of ^{14}C-profluralin by a mixed culture and 3 of 7 bacterial strains isolated from Cecil loamy sand. When incubated in liquid culture for 2-11 days, the isolated soil bacteria Arthrobacter simplex, Cellulomonas flavigenum and Microbacterium flavum produced metabolites that accounted for 1.0-4.1, 1.1-16.4 and 3.5-26.1% of the recovered radioactivity, respectively. The bacteria did not degrade profluralin when it was the sole source of carbon or nitrogen, indicating that co-metabolic processes were involved.

Jacobson et al. (1980) incubated 100 µg ^{14}C-profluralin/mL aerobically and anaerobically with samples of sterilized and viable primary effluent from a sewage treatment plant and found the compound to be co-metabolized. The amounts of radioactivity recovered in aerobic metabolic products after 18, 34, 55 and 88 days of incubation were 3.5, 27, 66 and 87%, respectively. The amounts of radioactivity recovered in anaerobic metabolic products after 18, 34, 55 and 88 days of incubation were 0.5, 2.8, 17 and 23%, respectively. When ^{14}C-profluralin was incubated for 24 hours with 40-fold concentrated sewage, four metabolic products accounting for 34% of the applied ^{14}C was recovered.

Profluralin is not expected to leach into groundwater or be carried from fields in runoff water unless soil movement or erosion takes place (WSSA, 1979).

Stralka and Camper (1981) reported significant loss of profluralin from sterile aqueous incubation mixtures. Within 3 days, 99% of the profluralin contained in the incubation mixtures was volatilized.

The fate of profluralin in an aquatic ecosystem was studied by Kearney et al. (1977). One hundred grams of soil treated with 100 ppm of profluralin plus a ^{14}C-profluralin tracer were placed in an aquarium to which 4 ℓ of water was added. Algae, snails and daphnia were added and the water was assayed for radioactivity for 30 days. Fish were added on the 30th day and all components were assayed for radioactivity on the 33rd day. Based on ^{14}C in water, the maximal profluralin concentration in water was 5.7 ppb. The bioaccumulation ratios of profluralin in algae, (washed) snails, daphnids and fish (Gambusia affinis) were 218, 339, 88 and 39, respectively. When Gambusia were maintained in a similar aquarium held in the dark for 3 days, a bioaccumulation factor of 535 was observed. When Gambusia and catfish were maintained in water containing 10 ppb profluralin, maximum bioaccumulation ratios of 1200 and 11,000, respectively, were observed. Water and fish extracts examined at the end of the experiment by thin layer chromatography revealed no parent profluralin and large amounts of polar decomposition products. Kenaga (1980) predicted BCFs for profluralin of 2260 and 670 based on the compound's water solubility and soil sorption coefficient, respectively.

3. EXPOSURE

Profluralin readily volatilizes from soil prior to incorporation. While this may be a significant source of exposure, no specific data regarding exposure to applicators were found in the available literature.

Profluralin may be absorbed by plants via their root systems, or by uptake of vapors by plant parts (Jacques and Harvey, 1979c); however, no data regarding residues in edible agricultural commodities were located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

4. PHARMACOKINETICS

4.1. ABSORPTION

Pertinent data regarding the absorption of profluralin by mammalian organisms were not located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

4.2. DISTRIBUTION

Pertinent data regarding the distribution of profluralin were not located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

4.3. METABOLISM

Nelson et al. (1977) have investigated the metabolism of profluralin by rat liver microsomes. Hepatic microsomes were obtained from both normal and pheno-barbital-pretreated male Sprague-Dawley rats. The major routes of metabolism were found to be N-dealkylation and aliphatic hydroxylation. Cyclization to form a benzimidazole was found to be a minor route of metabolism. The authors speculate that nitro-reduction may be a significant reaction; however, under the conditions of this assay, the products of nitro-reduction could be auto-oxidized to reform the nitro groups. If nitro-reduction is a major route of metabolism, then the intermediate hydroxylamine may represent a potentially mutagenic or carcinogenic metabolite.

4.4. EXCRETION

Pertinent data regarding the excretion of profluralin were not located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

5. EFFECTS

5.1. CARCINOGENICITY

Pertinent data regarding the carcinogenicity of profluralin were not located in the available literature. It is not scheduled for testing by the National Toxicology Program (NTP, 1983).

Bontoyan et al. (1979) found a sample of profluralin to be contaminated with 4 ppm N-nitrosocyclopropylmethyl-n-propylnitrosamine, CMPNA. Zweig et al. (1980) also report finding N-nitroso contaminants; however, they consider this contamination avoidable by process changes and elimination of nitrite salts in the formulation. The presence of nitrosamine contaminants is of concern, since many of these compounds are carcinogenic.

5.2. MUTAGENICITY

Pertinent data regarding the mutagenicity of profluralin in mammalian or bacterial test systems were not found in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

5.3. TERATOLOGY

Pertinent data regarding the teratogenicity of profluralin were not located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

5.4. OTHER REPRODUCTIVE EFFECTS

Pertinent data regarding other reproductive effects of profluralin were not located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

5.5. CHRONIC AND SUBCHRONIC TOXICITY

Pertinent data regarding the chronic or subchronic toxicity of profluralin were not located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

5.6. OTHER RELEVANT INFORMATION

Martin and Worthing (1977) report an acute oral LD_{50} of 10,000 mg/kg and an acute dermal LD_{50} of >3170 mg/kg in rats. No data on the acute toxicity of profluralin in man were located in the available literature.

6. AQUATIC TOXICITY

6.1. ACUTE TOXICITY

Pertinent data regarding the toxic effects of profluralin on aquatic vertebrates or invertebrates were not located in the available literature.

6.2. CHRONIC EFFECTS

Pertinent data regarding the effects of chronic exposure to profluralin on aquatic organisms were not located in the available literature.

6.3. PLANT EFFECTS

The toxicity of profluralin has been determined in two species of green algae, Chlorella pyrenoidosa and Chlorococcum sp., and two species of blue-green algae, Anabaena variabilis and Lyngbya sp. (Hawxby et al., 1977). After 24 hours of exposure to 0.0, 0.035, 0.347 and 3.473 mg profluralin/ℓ, growth was determined spectrophotometrically, and photosynthetic rate was measured using an oxygen electrode. Growth rates of Lyngbya sp. and A. variabilis were not affected by profluralin at the dose levels tested. Significantly decreased growth ($p<0.05$) was determined in C. pyrenoidosa at 3.473 mg/ℓ and in Chlorococcum sp. at all profluralin concentrations. Photosynthetic rate, however, was not affected by profluralin at the test concentrations in Chlorococcum sp. and Lyngbya sp. (Hawxby et al., 1977). At 3.473 mg profluralin/ℓ, oxygen production was decreased to 80% of control values ($p<0.05$) in A. variabilis. Photosynthetic rate was significantly reduced ($p<0.05$) in C. pyrenoidosa at 0.035, 0.347 and 3.473 mg profluralin/ℓ, with oxygen production being 64, 59 and 58% of controls, respectively (Hawxby et al., 1977).

6.4. RESIDUES

The persistence and bioaccumulation of profluralin in an aquatic environment has been examined by Kearney et al. (1977). Profluralin, introduced

into water from a treated loam-soil sample (100 g soil treated with 10 mg profluralin/ℓ), had not reached an equilibrium concentration after 30 days. Levels had reached 0.0057 mg/ℓ by this time. The concentration and BCF of profluralin, determined in algae, snails, daphnids and mosquitofish (Gambusia affinis) were 1.24 and 248, 1.93 and 339, 0.47 and 88, and 0.21 mg/ℓ and 39, respectively (Kearney et al., 1977).

6.5. OTHER RELEVANT INFORMATION

Additional data relevant to the toxic effects of profluralin on aquatic organisms were not located in the available literature (see Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation).

7. EXISTING GUIDELINES AND STANDARDS

7.1. HUMAN

The U.S. EPA has established a tolerance of 0.02 ppm for residues of profluralin in eggs, milk and the meat, fat and meat byproducts of cattle, goats, hogs, horses, poultry and sheep; 0.1 ppm in or on fresh alfalfa, alfalfa hay, cottonseed, safflower seed, dry or succulent agricultural commodity group seed and pod vegetables, seed and pod vegetable fodder and forage, and sunflower seed; and 0.3 ppm in or on soybean hay (40 CFR 180.348). The American Conference of Governmental Industrial Hygienists has not established a TLV for profluralin (ACGIH, 1980, 1982).

7.2. AQUATIC

Guidelines and standards for the protection of aquatic organisms from the toxic effects of profluralin have not been developed.

8. RISK ASSESSMENT

Pertinent data regarding the carcinogenicity of profluralin were not located in the available literature; however, possible carcinogenicity may be of concern when dealing with commercial mixtures, because of the presence of nitrosamines (see Section 5.1.). No data are available on which to base a q_1^*.

Pertinent data regarding the chronic or subchronic toxicity of profluralin were not located in the available literature; therefore, no ADI could be derived.

Statements concerning available literature in this document refer to published, quotable sources and are in no way meant to imply that confidential data, which this document could not address, are not in existence. These data, which are considered Classified Business Information (CBI), are available in summary form as a CBI Appendix that can be accessed by individuals with appropriate clearance. Conclusions from the CBI Appendix regarding risk assessment, however, can be presented in this chapter.

The CBI Appendix to this document reviews other animal studies from which an ADI can be derived. Based on a NOEL of 3 mg/kg/day in a subchronic feeding study in rats and using an uncertainty factor of 500, an ADI of 0.006 mg/kg/day or 0 42 mg/day for a 70 kg man is recommended.

The CBI Appendix also reviews animal data that indicate that profluralin may be carcinogenic to mice. A q_1^* for humans of 2.82×10^{-2} $(mg/kg/day)^{-1}$ was calculated from dose-response data for malignant hepatomas in mice fed profluralin in the diet. The q_1^* value was calculated using the linearized multistage model developed by Kenneth Crump and adopted by the U.S. EPA (Federal Register, 1980). The conversion factor used in the calculation of the q_1^* for humans (assuming 70 kg body weight) from animal data was the cube root of the body weight ratio (Federal Register, 1980).

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